D1 Servo Drive

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**D1 Servo Drive Technical Information**
# D1 Series Drive

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1. Features

■ Excellent Performance

The D1 drive attains high positioning performance to compliment the motion control technology of the semiconductor industry. The D1 drive achieves very good following characteristics and effectively shortens the positioning time.

■ Simple Operation

Human-machine interface provides very simple settings. All standard types of motors and encoders are built inside. Setup can be completed with just one-click.

■ Complete Tool Sets

There are test interfaces for speed and acceleration protection settings, gain settings, and an I/O test. Plus the D1 drive has a complete filter, frequency analysis, Bode plot, Lissajous figures and other functions which provide a complete drive control program.

■ Easy Integration

HIWIN provides positioning modules, motors, and the best servo drive solution from mega-fabs. According to customer’s requirements we can integrate all that are required for user’s easiness of application.

■ Services

Through HIWIN’s complete global presence, we can provide immediate technical services at any time.

■ EtherCAT

The D1 series delivers the high performance amplifier with EtherCAT interface
2. Application international Safety Standard

<table>
<thead>
<tr>
<th>EC Directives</th>
<th>EMC Directives</th>
<th>Drive</th>
<th>Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EN55011</td>
<td>EN55011</td>
<td>EN55011</td>
</tr>
<tr>
<td></td>
<td>EN61000-6-2</td>
<td>EN61000-6-2</td>
<td>EN61000-6-2</td>
</tr>
<tr>
<td></td>
<td>EN61000-6-4</td>
<td>EN61000-6-4</td>
<td>EN61000-6-4</td>
</tr>
<tr>
<td></td>
<td>EN61800-3</td>
<td>EN61800-3</td>
<td>EN61800-3</td>
</tr>
<tr>
<td>Low-Voltage Directives</td>
<td>EN61800-5-1</td>
<td>EN60034-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EN61000-6-2</td>
<td>EN61000-6-4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EN61800-3</td>
<td>EN61800-3</td>
<td></td>
</tr>
<tr>
<td>UL</td>
<td>UL508C</td>
<td>UL1004-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSA C22.2 NO.14-13</td>
<td>UL1004-6</td>
<td></td>
</tr>
</tbody>
</table>

3. Order Code

<table>
<thead>
<tr>
<th>Column</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>D</td>
<td>1</td>
<td>-</td>
<td>3</td>
<td>6</td>
<td>-</td>
<td>5</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Product
D1 ...................... =D1

Peak Current
9A ................................. =09
18A ................................. =18
36A ................................. =36

Interface
Standard/without communication interface.. ........... =S
EtherCAT[CoE]........................................................... =E
EtherCAT[mega-ulink] ............................................... =F

Encoder Type
Standard[Analog] ................................................................. =2
Standard[Digital] ................................................................. =3
Resolver ................................................................. =4

Voltage range
1Φ/3Φ 220V ................................................................. =2

Heat sink type
Without external heat sink................................................................. =0
High profile[H1] ................................................................. =1
Low profile[H2] ................................................................. =2

Reserved
Standard ................................................................................................................................................ =00
4. Overall Wiring

- Circuit Breaker (MCCB)
- Noise Filter (optional)
- Magnetic Contactor (MC)
- Reactor (L) (optional)
- Regenerative Risistor (optional)

Display Panel
- Two lines Dot Matrix indicates messages and parameters

Status LED
- Ready/Error quick guide

Connection to PC
- Use RS-232 cable
- Please download from www.hiwin.com.tw

Connection to host controller
- 26-pin SCSI connector (standard accessory)

Edge filter
- MF-40-S (optional)

DC 24V for brake
- (applied by customer)

MOTOR power end

Connection to Encoder
- Encoder cable (optional)
**mega-fabs D1 Servo Drive**

- Digital amplifier
- Field oriented control
- Intuitive Lightning interface
- 100-240VAC input power
- Supports Step/Direction, CW/CCW and A/B phase pulse format
- Supports analog and digital encoder

---

**Diagram:**

1. Motor Cable
2. Encoder Cable
3. RS-232 Cable
4. Regenerative Resistor
5. Controller Pulse Cable

---

**Connections:**

- CN1
- CN2
- CN3
- CN4

---

**Components:**

- LM STAGE
- Drive
- Option
- PC
- Motion Controller

---

**Wiring Diagram:**

- Main Power
- DC24V
- Pulse signal etc.
- Limit signals
4.1 Wiring Diagram

- Single-phase power (Brake without relay, using HIWIN motor)

**Single-Phase AC Power Input**

![Wiring Diagram]

- AC110/220 Source
- MCCB
- Line Filter
- MC
- L
- L3
- L2
- L1
- Motor Power Line
- Motor
- Edge Filter (Optional)
- Regen Resistor (Optional)
- Fuse
- REG+
- REG-
- Regen Circuit Loop
- Control Power Supply and Brake control output
- 24Vdc control power supply (Required) At least 1A
- Brake output wiring is decided by user (Optional)

--- Optional connected (Brake, Regen)
Three-phase power (Brake without relay, using HIWIN motor)

**Three-Phase AC Power Input**

- AC220
  - Source

- MCCB

- Line Filter

- MC

- L

- L1

- L2

- L3

- Main Power Supply

- Do not exceed 1M

- Motor

- Motor Power Line

- Edge Filter
  - (Optional)

- Regen Resistor
  - (Optional)

- Fuse

- REG+

- REG-

- Regen Circuit Loop

- +24Vdc control power supply (Required)
  - At least 1A

- +24V

- Control Power Supply and Brake control output

- BRK

- RTN

- 0V

- Brake output wiring is decided by user
  - (Optional)

- :Optional connected (Brake, Regen)
4.2 Control Circuit

- Wiring Example of Position Control Mode
  - Linear Motor Stage

**Description:**
Wiring example of Position Mode with linear motor. Pulse command input is differential signal.
- Direct Drive Motor

**Description:**
Wiring example of Position Mode with linear motor. Pulse command input is differential signal.
Description:
Wiring example of Velocity/Torque Mode with linear motor.
5. Drives

5.1 Basic Specifications

<table>
<thead>
<tr>
<th>Type: D1 series</th>
<th>Type: D1 series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>100 - 240 VAC ±10%</td>
</tr>
<tr>
<td>Frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Phase</td>
<td>1 Ø or 3 Ø</td>
</tr>
<tr>
<td>Control voltage</td>
<td>+24 Vdc ±10%</td>
</tr>
<tr>
<td>Control current</td>
<td>1A minimum</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power Output</th>
<th>Power Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous current</td>
<td>D1-09: 3Apk[2.12Arms]</td>
</tr>
<tr>
<td></td>
<td>D1-18: 6Apk[4.24Arms]</td>
</tr>
<tr>
<td></td>
<td>D1-36: 12Apk[8.5Arms]</td>
</tr>
<tr>
<td>(Note: External heat sink installed depending on application)</td>
<td></td>
</tr>
<tr>
<td>Peak current</td>
<td>D1-09: 9Apk[6.36Arms]</td>
</tr>
<tr>
<td></td>
<td>D1-18: 18Apk[12.7Arms]</td>
</tr>
<tr>
<td></td>
<td>D1-36: 36Apk[25.4Arms]</td>
</tr>
<tr>
<td>Continuous time of peak current</td>
<td>1 second</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Main loop control</th>
<th>IGBT PWM space vector control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of motor</td>
<td>AC servo motor, linear motor and torque motor</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Status LED</th>
<th>Non EtherCAT drive</th>
<th>Red: Error; Green: Servo Ready</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EtherCAT drive</td>
<td>Red: Error; Green: RUN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Position mode</th>
<th>Position mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>input port</td>
<td>[I9,I9M][I10,I10M] Differential or I9, I10 single end input</td>
</tr>
<tr>
<td>Pulse command mode</td>
<td>Pulse/Direction; CW/CCW; AqB</td>
</tr>
<tr>
<td>Maximum input frequency</td>
<td>differential Pulse [2M Pulses/s max.]; Quad A/B [8M counts/s max.];</td>
</tr>
<tr>
<td></td>
<td>Single end Pulse:[500K Pulses/s max.]; Quad A/B [2M counts/s max.];</td>
</tr>
<tr>
<td>Command generator</td>
<td>Pulse from host controller</td>
</tr>
<tr>
<td>Electrical gear ratio</td>
<td>Gear ratio: pulses / counts pulses:1-2147483647, counts:1-2147483647</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Control</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog</td>
<td>Input resistance: 10KΩ; Voltage: ±10 Vdc</td>
</tr>
<tr>
<td>Digital</td>
<td>Dual wire type: I9 : PWM = 0% - 100%; I10: Direction= 1/0</td>
</tr>
<tr>
<td></td>
<td>Single wire type: I9 : PWM = 50% ± 50%; I10: Nonfunctional</td>
</tr>
<tr>
<td></td>
<td>Operation range: 36.5KHz minimum, 100KHz maximum</td>
</tr>
<tr>
<td></td>
<td>Pulse width limit: 220 ns minimum</td>
</tr>
<tr>
<td>Command generator</td>
<td>Voltage or PWM from host controller</td>
</tr>
<tr>
<td><strong>Torque mode</strong></td>
<td>Analog Input Command</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Digital command format</td>
<td>Same as velocity mode</td>
</tr>
<tr>
<td>Command generator</td>
<td>Voltage or PWM from host controller</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Encoder Type</strong></th>
<th>Operation voltage</th>
<th>+5Vdc±5% ±400mA</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Encoder Type</strong></th>
<th>Digital</th>
<th>Analog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input signal</td>
<td>A, /A, B, /B, Z, /Z, RS422 differential signal</td>
<td></td>
</tr>
<tr>
<td>Bandwidth</td>
<td>5MHz line frequency, for AqB 20M Count/s</td>
<td></td>
</tr>
<tr>
<td>Input amplitude</td>
<td>1Vp-p [Sin/Cos], different signal</td>
<td></td>
</tr>
<tr>
<td>Bandwidth</td>
<td>1MHz maximum line [cycle] frequency</td>
<td></td>
</tr>
<tr>
<td>Resolution</td>
<td>Maximum 65528 Counts/cycle</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Resolver</strong></th>
<th>Resolution</th>
<th>12 bits (equivalent to a 1024 line quadrature encoder)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference frequency</td>
<td>5KHz</td>
<td></td>
</tr>
<tr>
<td>Reference voltage</td>
<td>6Vp-p</td>
<td></td>
</tr>
<tr>
<td>Reference maximum current</td>
<td>100mA</td>
<td></td>
</tr>
</tbody>
</table>

*Output of Feedback pulse*  
Maximum 18M Count/s, RS422 differential signal output, Scaling adjustment

<table>
<thead>
<tr>
<th><strong>Hall signal</strong></th>
<th>Single end signals with 120° phase difference: HA, HB, HC</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Communication</strong></th>
<th>Interface</th>
<th>RS232 to PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol</td>
<td>Full duplex, Baud rate: 115,200bps, Binary format</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Programmable I/O interface</strong></th>
<th>10 digital inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td>[I1-I6, I11, I12][I9, I10] -74HC14 Schmitt trigger input Note:[I9, I10] not for general purpose I/O under pulse mode</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Programmable I/O interface</strong></th>
<th>3 digital outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3Adc max</td>
<td>+40Vdc max [Open Drain]</td>
</tr>
<tr>
<td>[O1], [O2], [O3]</td>
<td></td>
</tr>
<tr>
<td>Brake output</td>
<td>BRAKE [O4], 1Adc max</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>PDL</strong></th>
<th>Maximum code size</th>
<th>32K Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable storage capacity</td>
<td>800 Bytes</td>
<td></td>
</tr>
<tr>
<td>Support variable type</td>
<td>Floating: 32 bits</td>
<td></td>
</tr>
<tr>
<td>Integer: 16 and 32 bits; array and point</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Execution cycle</td>
<td>66.67us</td>
<td></td>
</tr>
<tr>
<td>Multitasking features</td>
<td>Execute 4 Task at the same time</td>
<td></td>
</tr>
<tr>
<td>instructions</td>
<td>if, else, while loop, for loop, goto and till</td>
<td></td>
</tr>
<tr>
<td>Operators</td>
<td>Contains the basic arithmetic operators, logical operators, comparison operators</td>
<td></td>
</tr>
<tr>
<td>Character length limitations</td>
<td>variable : 17, label : 24, proc : 24</td>
<td></td>
</tr>
<tr>
<td>Regen Circuit</td>
<td>Resistor</td>
<td>External</td>
</tr>
<tr>
<td>--------------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>Turn on voltage</td>
<td>+HV &gt; 390 Vdc</td>
<td></td>
</tr>
<tr>
<td>Turn off voltage</td>
<td>+HV &lt; 380 Vdc</td>
<td></td>
</tr>
<tr>
<td>DC Bus capacitance</td>
<td>940uF/9A.18A 1880uF/36A</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Protection</th>
<th>Short, Over voltage(&gt; 400Vdc), Position error too big, Encoder error, Motor cable lost connection, Drive over-temperature(IGBT &gt; 80°C ± 3°C), Motor over-temperature, Under voltage(&lt; 60Vdc)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Error Mapping</th>
<th>Applies to Linear motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>Established compensation table to compensate encoder error by linear interpolation</td>
</tr>
<tr>
<td>Samples</td>
<td>Maximum 5,000 points</td>
</tr>
<tr>
<td>Storage</td>
<td>Flash ROM, Disc file</td>
</tr>
<tr>
<td>Unit</td>
<td>um, count</td>
</tr>
<tr>
<td>Activation</td>
<td>Activated internally by home complete, or activated externally by input signal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>functional frequency range of VSF</th>
<th>0.1Hz~200Hz</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Environment</th>
<th>Operation Temperature 0~50°C (if over 55°C, air circulation is needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Temperature</td>
<td>-20°C ~65°C</td>
</tr>
<tr>
<td>Humidity</td>
<td>0 to 90%RH</td>
</tr>
<tr>
<td>Elevation</td>
<td>Under 1000 Meters</td>
</tr>
<tr>
<td>Vibration</td>
<td>1G (10 to 500Hz)</td>
</tr>
<tr>
<td>IP Code</td>
<td>IP20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cooling System</th>
<th>Natural circulation and to install two types of heat sink</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>1,250 g/min</td>
</tr>
<tr>
<td>Dimension</td>
<td>191.6mm X 139.8 mm X 64.8 mm</td>
</tr>
<tr>
<td>Chassis</td>
<td>Compliance with U.L. Spec 94 V-0 Flammability Rating</td>
</tr>
</tbody>
</table>

* - Only for non EtherCAT drive
5.2 Dimensions of drive

- [D1-xx-xx-x-0-xx]

- [D1-xx-xx-x-1-xx]
6. Accessories

6.1 Motor Power Cable

<table>
<thead>
<tr>
<th>Part name</th>
<th>Type</th>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor cable</td>
<td>Linear</td>
<td>LMACS □□ D</td>
<td>For LMS series linear motor and motor OT cable included</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LMACS □□ K</td>
<td>For LMCA-LMCD, LMT series linear motor and motor OT cable included</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LMACS □□ L</td>
<td>For LMCF series linear motor and motor OT cable included</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LMACS □□ H</td>
<td>For LMSA series linear motor and motor OT cable included</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LMACS □□ J</td>
<td>For LMF series linear motor and motor OT cable included</td>
</tr>
<tr>
<td>Torque</td>
<td></td>
<td>LMACS □□ F</td>
<td>For TMS, TMN, TMY series torque motor</td>
</tr>
</tbody>
</table>

□□ Represents cable length as the following:

<table>
<thead>
<tr>
<th>Cable length(m)</th>
<th>03</th>
<th>04</th>
<th>05</th>
<th>06</th>
<th>07</th>
<th>08</th>
<th>09</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

6.2 Feedback Signal Cables

<table>
<thead>
<tr>
<th>Part name</th>
<th>Type</th>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder Cable</td>
<td>Linear</td>
<td>LMACE □□ Y</td>
<td>For Renishaw Digital Encoder, motor OT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LMACE □□ Z</td>
<td>For Renishaw Digital Encoder, motor OT, and digital hall sensors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LMACE □□ C</td>
<td>For Renishaw Analog Encoder, motor OT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LMACE □□ J</td>
<td>For Renishaw Analog Encoder, motor OT, and digital hall sensors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LMACE □□ AW</td>
<td>For Renishaw Digital Encoder, motor OT, with Encoder alarm, with Encoder alarm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LMACE □□ AV</td>
<td>For Renishaw Digital Encoder, motor OT, and digital hall sensors, with Encoder alarm</td>
</tr>
<tr>
<td></td>
<td>Rotary</td>
<td>LMACE □□ AA</td>
<td>For Jena Analog Encoder, motor OT. For TMS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LMACE □□ AM</td>
<td>For Jena Analog Encoder, motor OT. For TMS, and digital hall sensors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LMACE □□ AU</td>
<td>For Dual Resolver</td>
</tr>
</tbody>
</table>

□□ Represents cable length as the following:

<table>
<thead>
<tr>
<th>Cable length(m)</th>
<th>03</th>
<th>04</th>
<th>05</th>
<th>06</th>
<th>07</th>
<th>08</th>
<th>09</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>
### 6.3 Control Signal Cables

<table>
<thead>
<tr>
<th>Part name</th>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Cable</td>
<td>LMACK30R</td>
<td>For motion controller (about 3m long)</td>
</tr>
<tr>
<td></td>
<td>LMACK □□ A</td>
<td>For ACS SPiiPlus SA motion controller</td>
</tr>
</tbody>
</table>

□□ Represents cable length as the following:

<table>
<thead>
<tr>
<th></th>
<th>03</th>
<th>04</th>
<th>05</th>
<th>06</th>
<th>07</th>
<th>08</th>
<th>09</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable length (m)</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

### 6.4 RS232 Communication Cable

<table>
<thead>
<tr>
<th>Part name</th>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS232 communication cable</td>
<td>LMACR21D</td>
<td>Cable length is 2 meters long and connector type RJ11 at the drive side</td>
</tr>
<tr>
<td>Ethercat communication</td>
<td>HE00834D8400</td>
<td>Cable length is 0.2 meters long and connector type RJ45 at the drive side(For Ethercat communication between the drive)</td>
</tr>
<tr>
<td>Ethercat communication</td>
<td>HE00834D8500</td>
<td>Cable length is 3 meters long and connector type RJ45 at the drive side(For Ethercat communication between the drive)</td>
</tr>
</tbody>
</table>

### 6.5 Accessory Pack of Connector

<table>
<thead>
<tr>
<th>Part name</th>
<th>Model</th>
<th>Description</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessory Pack (without CN3)</td>
<td>D1-CK1</td>
<td>AC main power connector: 4 pins and pitch 7.5mm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motor cable connector: 4 pins and pitch 5mm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Regenerative resister connector: 3 Pin and pitch 7.5mm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24V dc power and brake connector: 3 pins and pitch 5mm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN2 control signal connector: MDR 26P</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Connector tool</td>
<td>2</td>
</tr>
<tr>
<td>Accessory Pack (CN3 connector included)</td>
<td>D1-CK2</td>
<td>AC main power connector: 4 pins and pitch 7.5mm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motor cable connector: 4 pins and pitch 5mm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Regenerative resister connector: 3 pins and pitch 7.5mm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24V dc power and brake connector: 3 pins and pitch 5mm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Connector tool</td>
<td>2</td>
</tr>
</tbody>
</table>
6.6 EMC Accessory Pack

<table>
<thead>
<tr>
<th>Part name</th>
<th>Model</th>
<th>Description</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC accessory for EMI core</td>
<td>EMI Core (050300400026)</td>
<td>EMI core KCF-130-B (EMI core can use for drive power input/output cables and signal cables to decrease noise)</td>
<td>1</td>
</tr>
<tr>
<td>EMC accessory pack for single phase</td>
<td>D1-EMC1 (051800200063)</td>
<td>Single phase filter FN2090-10-06 (051800200044) (Rated current: 6A, leakage current: 0.67mA)</td>
<td>1</td>
</tr>
<tr>
<td>EMC accessory pack for three phase</td>
<td>D1-EMC2 (051800200062)</td>
<td>Three phase filter FN3258-7-45 (051800200060)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>D1-EMC3 (051800200083)</td>
<td>Single phase filter FNFN3258-20-71 (Low leakage current) (051800200071)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>MF-40-S (FF000MF11001)</td>
<td>Edge filter MF-40-S (Used to minimize the differential and common mode noise on the output of any D1 drive)</td>
<td>1</td>
</tr>
</tbody>
</table>

- **Single phase filter (D1-EMC1)**
  - Dimensions: 113.5 x 103 x 94 x 4.4 x 6.3 x 0.8
  - (Unit:mm)

- **Three phase filter (D1-EMC2)**
  - Dimensions: 160 x 190 x 4.5
  - (Unit:mm)
- Edge filter (MF-40-S)

- Three phase filter (D1-EMC3)
6.7 Other Accessories

<table>
<thead>
<tr>
<th>Part name</th>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regenerative</td>
<td>RG1</td>
<td>68Ω, Rated power 100W and peak 500W</td>
</tr>
<tr>
<td>Heat sink</td>
<td>D1-H1</td>
<td>High profile</td>
</tr>
<tr>
<td></td>
<td>D1-H2</td>
<td>Low profile</td>
</tr>
</tbody>
</table>

**Regenerative resistor**

(Unit:mm)  
D1-DNE03A

(Unit:mm)  
D1-DNE02B
■ Heat sink

- D1-H1

- D1-H2
7. Motor Line-up

- **D1-XX-X2 or D1-XX-X3 for Linear motors**
  - **LMC**:
    - LMC-EFC1, LMC-EFC2, LMC-EFC3, LMC-EFC4, LMC-EFE6, LMCA2, LMCA3, LMCA4, LMCA5, LMCA6, LMCA8, LMCB2, LMCB3, LMCB4, LMCB5, LMCB6, LMCB7, LMCA, LMCC7, LMCD4, LMCD6, LMCD8, LMCD9, LMCE4, LMCE6, LMCE8, LMCEA, LMCEC, LMCF4, LMCF6
  - **LMS**:
    - LMSC7, LMSC7(WC)
  - **LMFA**:
    - LMFA0x, LMFA1x, LMFA2x, LMFA3x, LMFA4x, LMFA5x, LMFA6x
  - **LMSA**:
    - LMSA1x, LMSA2x, LMSA3x, LMSACx
  - **LMT**:
    - LMT2D, LMT2O, LMT2T, LMTA3, LMTA4, LMTA6, LMTB3, LMTB4, LMTC2, LMTA, LMTA3, LMTA4, LMTB2, LMTB3, LMTB4, LMTC2, LMTC3, LMTC4, LMTD2, LMTD3, LMTD4

- **D1-XX-X2 for Torque motors**
  - **TMS**:
    - TMS0x, TMS1x, TMS3x, TMS7x
  - **TMN**:
    - TMNxxE

- **D1-XX-X4 for Absolute Resolver Torque motors**
  - **TMY**:
    - TMY4x, TMY6x, TMYAx
  - **TMN**:
    - TMNxxA

*Note* Please contact with Sales Represent
8. Selecting motor capacity guide

8.1 Motor Sizing

Start Motor Sizing
The following contents describe how to choose proper motor according to speed, moving distance, and loading inertia. The basic process for sizing a motor is:
- Decide motion profile and required parameters
- Calculate peak and continuous force
- Select motor

Symbols
X : move distance [mm]
T : move time [sec]
a : acceleration [mm/s²]
V : velocity [mm/s]
M_L : loading [kg]
g : gravitation acceleration [mm/s²]
F_p : peak force [N]
F_c : continuous force [N]
F_a : attraction force between stator and force [applicable for LMS, LMF series] [N]
F_i : inertia force [N]
K_p : force constant [N/Arms]
I_p : peak current [Arms]
I_e : effective current [Arms]
I_c : continuous current [Arms]
V_0 : starting velocity [mm/s]

STEP 1 Decide motion velocity profile and required parameters
In order to determine the correct motor for a particular application it is necessary to be familiar with the motion equation.

Motion equation
Basic kinematics equations are described as follows:
\[ V = V_0 + aT \]
\[ X = V_0T + \frac{1}{2}aT^2 \]
Where \( V \) is velocity, \( a \) is acceleration, \( T \) is move time and \( X \) is move distance.
You can choose two of the four parameters \( \{V, a, T \text{ and } X\} \) as your designed parameters, then the last two parameters can be calculated by above equations.
■ Motion velocity profile
1. 1/3-1/3-1/3 trapezoid profile
If the distance (X) and move time (T) have been given, the most common and efficient velocity profile for point-to-point motion is the “1/3-1/3-1/3” trapezoid curve because it provides the optimal move by minimizing the power required to complete the move. It breaks the time of the acceleration, traveling, and deceleration into three segments as shown below.

\[ V_{\text{max}} = 1.5 \times \frac{X}{T} \quad (\text{Because } X = \frac{V}{2} \times \frac{T}{3} + V \times \frac{T}{3} + \frac{V}{2} \times \frac{T}{3}) \]

\[ a_{\text{max}} = \frac{V_{\text{max}}}{\frac{T}{3}} = \frac{4.5X}{T^2} \]

Herein the parameters are described as motion equation.

2. 1/2-1/2 triangle profile
If X and T are given, another common motion profile is the 1/2-1/2 triangle profile. The motion is divided into two parts, namely acceleration and deceleration. The second motion velocity profile is shown as follows.

\[ V_{\text{max}} = 2 \times \frac{X}{T} \]

\[ a_{\text{max}} = \frac{4X}{T^2} \]

The acceleration required in the first motion velocity profile is bigger than that in the second motion velocity profile; therefore, the required motor size is bigger. When choosing second motion velocity profile, the chosen motor size is smaller, however, we need to verify the DC bus of drive is bigger enough, due to the higher velocity (V_{\text{max}}).
3. Some useful equations

<table>
<thead>
<tr>
<th>1/3 - 1/3 - 1/3 Trapezoid profile</th>
<th>Triangle profile</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Trapezoid profile diagram" /></td>
<td><img src="image" alt="Triangle profile diagram" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V</th>
<th>1.5 × X / T</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>4.5X / T²</td>
</tr>
<tr>
<td>t</td>
<td>X / V_max + V_max / a (if X / V_max ≥ V_max / a)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V (m/sec)</th>
<th>T/3</th>
<th>T/3</th>
<th>T/3</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_max</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t(sec)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**STEP 2 Determine peak force and effective force**

The peak force can be calculated by the following equation:

\[ F_p = M_L \times a_{max} + (M_L \times g + F_a) \times \mu = F_i + F_f \]

Where \( F_i \) is inertia force while \( F_f \) is friction force, and \( \mu \) is friction factor.

In most cases, motions are cyclic point-to-point movements. Assuming a cyclic motion shown in the following profile with a pause time of \( t_4 \) second, the effective force can be calculated as following formula:

\[ F_e = \sqrt{\frac{(F_i + F_f)^2 t_1 + F_f^2 t_2 + (F_i - F_f)^2 t_3}{t_1 + t_2 + t_3 + t_4}} \]

<table>
<thead>
<tr>
<th>V (m/sec)</th>
<th>t1</th>
<th>t2</th>
<th>t3</th>
<th>t4</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_max</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t(sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The peak current \( I_p \) and effective current \( I_e \) can be calculated by using motor force constant \( K_f \).

\[ I_p = \frac{F_p}{K_f} \]

\[ I_e = \frac{F_e}{K_f} \]
STEP 3 Select motor by peak force and verify the current supply of motor

From the catalog of HIWIN, you can check the specifications of motor and choose an applicable motor by peak force, and then you can verify the current supply if it is fitted the specification as follows.

\[ I_p = \frac{F_p}{K_t} < I_p \] (from specification of chosen motor)

\[ I_c = \frac{F_c}{K_t} < I_c \] (from specification of chosen motor)

Regarding effective and continuous current, the ratio of \( I_e/I_c \) had better be less than 0.7 to attain some margin.

Linear motor sizing example

For example, if load is 5 kg (moving mass of mechanism is 1 kg and payload is 4 kg), friction factor \( \mu \) is 0.01, distance is 500 mm, move time is 400 ms and dwell time is 350 ms.

At first, we can calculate the \( V_{max} \), \( a_{max} \), \( F_p \) and \( F_e \) by the formulas described above (choose the first motion velocity profile and LMC series)

\[ V_{max} = 1.5 \times \frac{X}{T} = 1.5 \times \frac{0.5}{0.4} = 1.875 \text{ (m/sec)} \]

\[ a_{max} = 4.5 \times \frac{X}{T^2} = \frac{4.5 \times 0.5}{(0.4)^2} = 14.06 \text{ (m/sec}^2) \]

\[ F_p = M_p \times a_{max} + (M_p \times g + F_x) \times \mu = 5 \times 14.06 + 5 \times 9.81 \times 0.01 = 70.3 + 0.49 = 70.79 \text{ (N)} \]

\[ F_e = \sqrt{[(70.3 + 0.49)^2 + 0.49^2 + (70.3 - 0.49)^2]} \times 0.1333 \]

\[ = 41.92 \text{ (N)} \]

In this case, we can choose motor of type LMCA6 (p.48) which can provide up to 187[N] of peak force and continuous force 62[N], and the force constant is 33.8 N/A(rms). Then the current supply of motor can be determined as follows

\[ I_p = \frac{F_p}{K_t} = \frac{70.79}{33.8} = 2.09 \text{ (Arms)< 5.4 (Arms)} \]

\[ I_p = \frac{F_p}{K_t} = \frac{41.92}{33.8} = 1.24 \text{ (Arms)< 1.8 (Arms)} \]

\[ I_c = \frac{1.24}{1.8} \times 100% = 68.89% < 70% \]
8.2 Sizing a Regenerative Resistor

- **Gather required information**
  To calculate the power and resistance of the regen resistor requires information about the amplifier and the motor. For all applications, gather the following information:

  - Detail of motion profile, including acceleration and velocity
  - Amplifier model number
  - Applied line voltage to amplifier
  - Torque/force constant of the motor
  - Resistance (line-to-line) of the motor windings

  For rotary motor applications, gather additional information
  - Load inertia seen by the motor
  - Inertia of the motor

  For linear motor applications, gather additional information
  - Moving mass

- **Observe the properties of each deceleration during a complete cycle of operation**
  For each deceleration during the motion cycle, determine:
  - Speed at the start of the deceleration
  - Speed at the end of the deceleration
  - Time over which the deceleration takes place

- **Calculate energy returned for each deceleration**
  The energy returned during each deceleration can be calculated by the following formulas.
  Rotary motor:
  \[ E_{\text{dec}} = \frac{1}{2} J_1 (\omega_1^2 - \omega_2^2) \]
  \( E_{\text{dec}} \) (joules): Energy returned by the deceleration
  \( J_1 \) (kg m²): Load inertia on the motor shaft plus the motor inertia
  \( \omega_1 \) (radians /sec): Shaft speed at the start of deceleration
  \( \omega_2 \) (radians /sec): Shaft speed at the end of deceleration
  \( I_e \) : effective current (Arms)

  Linear motor:
  \[ E_{\text{dec}} = \frac{1}{2} M_t (V_1^2 - V_2^2) \]
  \( E_{\text{dec}} \) (joules): Energy returned by the deceleration
  \( M_t \) (kg): Moving mass
  \( V_1 \) (meters /sec): Velocity at the start of deceleration
  \( V_2 \) (meters /sec): Velocity at the end of deceleration

- **Determine the amount of energy dissipated by the motor**
  Calculate the amount of energy dissipated by the motor due to current flow through the motor winding resistance using the following formula.
  \[ P_{\text{motor}} = \frac{3}{4} R_{\text{winding}} \left(\frac{F}{K_1}\right)^2 \]
  \( P_{\text{motor}} \) (watts): Power dissipated in the motor
D1 Series Drive

\[ \omega \]

\[ \omega = J_2 \tfrac{V_{VM2}}{2} \left( 1 + \frac{K_F}{R_4} \right) \]

\[ \omega = \frac{V_{VR} (72.02/0.4)}{TEP_{51.98}} = 72.02 \text{ (Watt)} / \text{TEP_{51.98}} \]

||
| \text{Energy returned to the amplifier} |
| \text{Energy returned to the amplifier} |

\[ E_{\text{motor}} = P_{\text{motor}} T_{\text{decel}} \]

\[ E_{\text{motor}} \] (joules): Energy dissipated in the motor

\[ T_{\text{decel}} \] (seconds): Time of deceleration

\[ E_{\text{returned}} = E_{\text{dec}} - E_{\text{motor}} \]

\[ E_{\text{returned}} \] (joules): Energy returned to the amplifier

\[ E_{\text{dec}} \] (joules): Energy returned by the deceleration

\[ E_{\text{motor}} \] (joules): Energy dissipated by the motor

\[ W_{\text{capacity}} = \frac{1}{2} C \left( V_{\text{regen}} - (1.414 V_{\text{mains}})^3 \right) \]

\[ W_{\text{capacity}} \] (joules): The energy that can be absorbed by the bus capacitor

\[ C \] (farads): Bus capacitance

\[ V_{\text{regen}} \] (volts): Voltage at which the regen circuit turns on

\[ V_{\text{mains}} \] (volts): Mains voltage (AC) applied to the amplifier

\[ E_{\text{regen}} = E_{\text{returned}} - E_{\text{amp}} \]

\[ E_{\text{regen}} \] (joules): Energy that must be dissipated in the regen resistor

\[ E_{\text{amp}} \] (joules): Energy that the amplifier will absorb

\[ P_{\text{pulse}} = \frac{E_{\text{regen}}}{T_{\text{decel}}} \]

\[ P_{\text{pulse}} \] (watts): Pulse power

\[ E_{\text{regen}} \] (joules): Energy that must be dissipated in the regen resistor

\[ T_{\text{decel}} \] (seconds): Time of deceleration

\[ R = \frac{V_{\text{regen}}^2}{P_{\text{pulse max}}} \]

\[ R \] (ohm): Line to Line resistance of the motor coil

\[ F \]: Force need to decelerate the motor

Nm for rotary applications
N for linear applications

\[ K_t \]: Torque constant for the motor

Nm/Amp for rotary applications
N/Amp for linear applications

\[ E_{\text{motor}} = P_{\text{motor}} T_{\text{decel}} \]

\[ E_{\text{motor}} \] (joules): Energy dissipated in the motor

\[ T_{\text{decel}} \] (seconds): Time of deceleration

Determine the amount of energy returned to the amplifier

Calculate the amount of energy that will be returned to the amplifier for each deceleration using the following formula

\[ E_{\text{returned}} = E_{\text{dec}} - E_{\text{motor}} \]

\[ E_{\text{returned}} \] (joules): Energy returned to the amplifier

\[ E_{\text{dec}} \] (joules): Energy returned by the deceleration

\[ E_{\text{motor}} \] (joules): Energy dissipated by the motor

Determine if energy returned exceeds amplifier capacity

Compare the amount of energy returned to the amplifier in each deceleration with the amplifier’s absorption capacity. The following formula is used to determine the energy that can be absorbed by the amplifier.

\[ W_{\text{capacity}} = \frac{1}{2} C \left( V_{\text{regen}} - (1.414 V_{\text{mains}})^3 \right) \]

Calculated energy to be dissipated for each deceleration

For each deceleration where the energy exceeds the amplifier’s capacity, using the following formula to calculate the energy that must be dissipated by the regen resistor.

\[ E_{\text{regen}} = E_{\text{returned}} - E_{\text{amp}} \]

\[ E_{\text{regen}} \] (joules): Energy that must be dissipated in the regen resistor

\[ E_{\text{returned}} \] (joules): Energy delivered back to the amplifier from the motor

\[ E_{\text{amp}} \] (joules): Energy that the amplifier will absorb

Calculate pulse power of each deceleration that exceeds amplifier capacity

For each deceleration where energy must be dissipated by the regen resistor, use the following formula to calculate the pulse power that will be dissipated by the regen resistor

\[ P_{\text{pulse}} = \frac{E_{\text{regen}}}{T_{\text{decel}}} \]

\[ P_{\text{pulse}} \] (watts): Pulse power

\[ E_{\text{regen}} \] (joules): Energy that must be dissipated in the regen resistor

\[ T_{\text{decel}} \] (seconds): Time of deceleration

Calculate resistance needed to dissipate the pulse power

Using the maximum pulse power from the previous calculation, calculate the resistance value of the regen resistor required to dissipate the maximum pulse power.

\[ R = \frac{V_{\text{regen}}^2}{P_{\text{pulse max}}} \]
Choose a standard value of resistance less than the calculated value. The value must also be greater than the minimum regen resistor value specified by the amplifier supplier.

### Regenerative resistor sizing example

Gather required information:

**LM ROBOTS type:** LMXL1L-S37L-1200-G200
**Amplifier:** mega-fabs D1
  - DC bus capacitance: 1880uF
  - Regen circuit turn on voltage: 390V
  - Minimum resistance: 15Ω
**Moving mass:** 86Kg (include payload 74 Kg)
**Vmax:** 2 m/s
**Acceleration, deceleration:** 5 m/s²
**Power supply (AC) of drive:** 220VAC
**Motor type:** LMS37L
**Force constant (Kf):** 68N/A[rms]
**R(winding):** 2 ohms [line-to-line]

Calculate regen resistor as following step:

\[
F = ma = 86 \times 5 = 430 \text{(N)}
\]

\[
E_{\text{dec}} = \frac{1}{2}mV^2 = \frac{1}{2} \times 86 \times 2^2 = 172 \text{(joule)}
\]

\[
P_{\text{motor}} = \frac{3}{4} \times R_{\text{winding}} \left( \frac{F}{K_f} \times \sqrt{2} \right)^2 = \frac{3}{4} \times 2 \times \left( \frac{430}{68} \times \sqrt{2} \right)^2
\]

\[
= 120 \text{(Watt)}
\]

\[
E_{\text{motor}} = P_{\text{motor}} \times T_{\text{dec}} = 120 \times \left( \frac{2}{5} \right) = 48 \text{(joule)}
\]

\[
E_{\text{returned}} = E_{\text{dec}} - E_{\text{motor}} = 172 - 48 = 124 \text{(joule)}
\]

\[
W_{\text{capacity}} = \frac{1}{2} \times C \times \left( V_{\text{regen}}^2 - (1.414V_{\text{mains}})^2 \right)
\]

\[
= \frac{1}{2} \times 1880 \times 10^{-6} \times (390^2 - (1.414 \times 220)^2)
\]

\[
= 51.98 \text{(joule)}
\]

\[\therefore \quad E_{\text{returned}} = W_{\text{capacity}}\]

\[
E_{\text{regen}} = E_{\text{returned}} - E_{\text{amp}} = 124 - 51.98 = 72.02 \text{(joule)}
\]

\[
P_{\text{pulse}} = \frac{E_{\text{regen}}}{I_{\text{pulse}}} = 72.02/0.4 = 180.05 \text{(Watt)}
\]

\[
R = \frac{V_{\text{pulse}}^2}{P_{\text{pulse}}} = \frac{390^2}{180.05} = 844.77 \text{(ohms)}
\]

Because the total value of selected resistance must be less than 844.77 ohms and the power capacity must be more than 180.05 watts, we choose two resistors and connect them in series, in each resistor the resistance is 68 ohms and power capacity is 100W. The total resistance value is 136 ohms and power capacity is 200W. The resistance order number is 050100700001.
## 9. Linear Motor Requirements List

<table>
<thead>
<tr>
<th>Company name</th>
<th>Contact person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Email</td>
<td>Tel</td>
</tr>
</tbody>
</table>

### Industrial

- **Environment**
  - [ ] Normal environment
  - [ ] Clean room, class
  - [ ] Other ______

- **Stage type**
  - [ ] Single axis
  - [ ] XY axis
  - [ ] Bridge type
  - [ ] Gantry (Single drive)
  - [ ] Gantry (Dual drive)
  - [ ] Other ______

- **Load (kg) or Moment of inertia (kg-m²)**

- **Max. Velocity (m/s) or (rad/s)**

- **Max. Acceleration (m/s²) or (rad/s²)**

- **Stroke (mm)**

- **Repeatability (μm) or (deg)**

- **Accuracy (μm) or (deg)**

- **Encoder type**
  - [ ] Analog
  - [ ] Pitch ______ μm
  - [ ] Digital
  - [ ] resolution ______ μm

- **Orientation of Stage**
  - [ ] Horizontal
  - [ ] Vertical
  - [ ] Laterally
  - [ ] Upside-down

- **Multiple forcer**
  - [ ] Yes, Number : ______
  - [ ] No

- **Dust-proof device**
  - [ ] No
  - [ ] Cover
  - [ ] Bellow

- **Cable Chain**
  - [ ] No
  - [ ] Horizontal
  - [ ] Vertical

- **Drive voltage**
  - [ ] 110V
  - [ ] 220V
  - [ ] Other ______ V

- **Pulse format**
  - [ ] CW/CCW
  - [ ] A/B
  - [ ] STEP/DIR

- **Application**
  - [ ] Point to point
  - [ ] Scan

### Special measurement requirement

The information below is to be filled out by our authorized agents.

Recommended specification:

---

**Manager:** ____________________________  **Engineer:** ____________________________  **Salesperson:** ____________________________
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